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(54) **BOILING WATER REACTOR CORE SHROUD HEAD BOLT RETAINER TOOL**

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B23P 19/04	(2006.01)
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B25B 29/02	(2006.01)
B25B 27/02	(2006.01)
G21C 19/20	(2006.01)

(52) **U.S. Cl.**

CPC ***B25B 27/023*** (2013.01); *Y10T 29/531* (2015.01); *Y10T 29/49826* (2015.01); ***G21C 19/20*** (2013.01); *G21C 19/207* (2013.01)

(58) **Field of Classification Search**

CPC .. B25B 27/023; B25B 27/14; B25B 27/0007; B25B 31/00; G21C 19/20; G21C 19/207

USPC 29/723, 255, 260, 261, 270, 278; 81/57.38, 484, 177.1, 177.6

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,200,484	A	8/1965	Garman	
3,722,332	A	3/1973	Jones	
3,847,041	A	11/1974	Meschonat	
4,166,313	A	9/1979	Walton	
4,219,386	A	8/1980	Osborne	
4,499,796	A	2/1985	Miller	
4,548,103	A	10/1985	Orban	
4,552,038	A	11/1985	Heiermann	
4,672,731	A	6/1987	Taylor	
4,991,280	A	2/1991	Reimer	
5,734,690	A	3/1998	Sakamaki	
6,076,437	A	6/2000	Saint Martin	
6,266,860	B1 *	7/2001	Kiebler	29/259
7,246,547	B2	7/2007	Van Walraven	
7,757,779	B2 *	7/2010	Jacobsson et al.	173/17

OTHER PUBLICATIONS

International Preliminary Report on Patentability for PCT Application No. PCT/US2012/50075, dated Feb. 11, 2014.

International Search Report for PCT Application No. PCT/US2012/50075, dated Mar. 29, 2013.

Written Opinion for PCT Application No. PCT/US2012/50075, dated Mar. 29, 2013.

* cited by examiner

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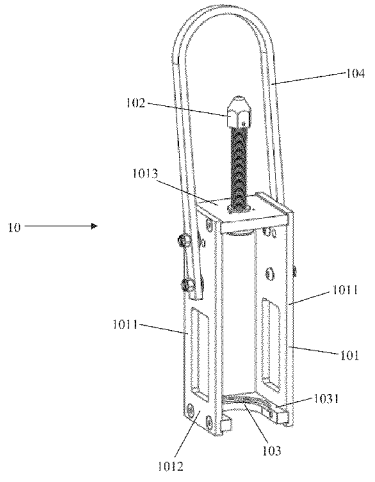
(57) **ABSTRACT**

The inventive tool is designed to ensure proper plant operation position of the core shroud head bolt assemblies of a boiling water nuclear reactor. The tool exerts an upward pulling force on stuck retainers to return them to the locking position around the nut. The tool includes a frame, an engagement member, and a collar. The engagement member is lowered toward and end of the bolt until it comes into contact therewith. Further movement of the engagement member causes the frame and collar to move upward, lifting the retainer and extending the spring.

1 Claim, 4 Drawing Sheets



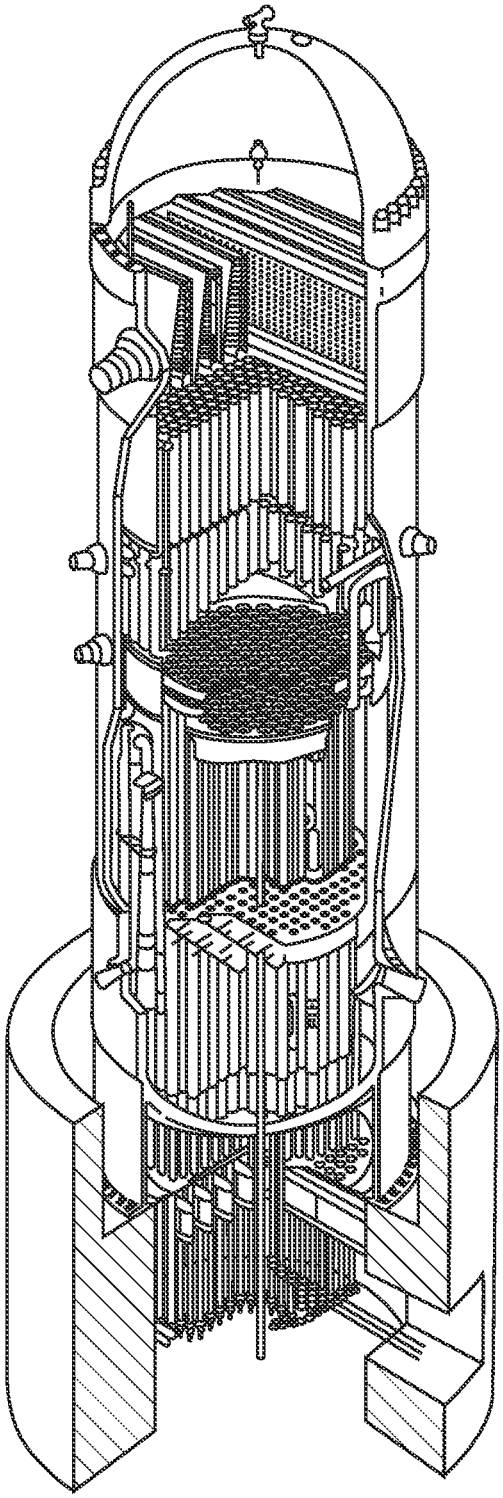


FIG. 1

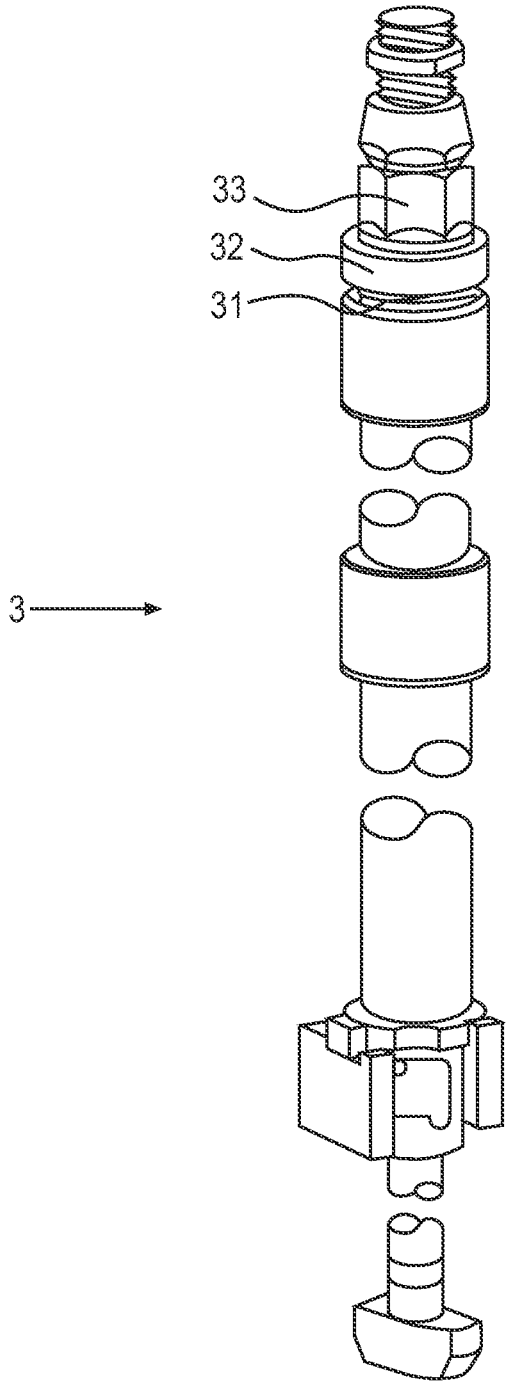


FIG. 2

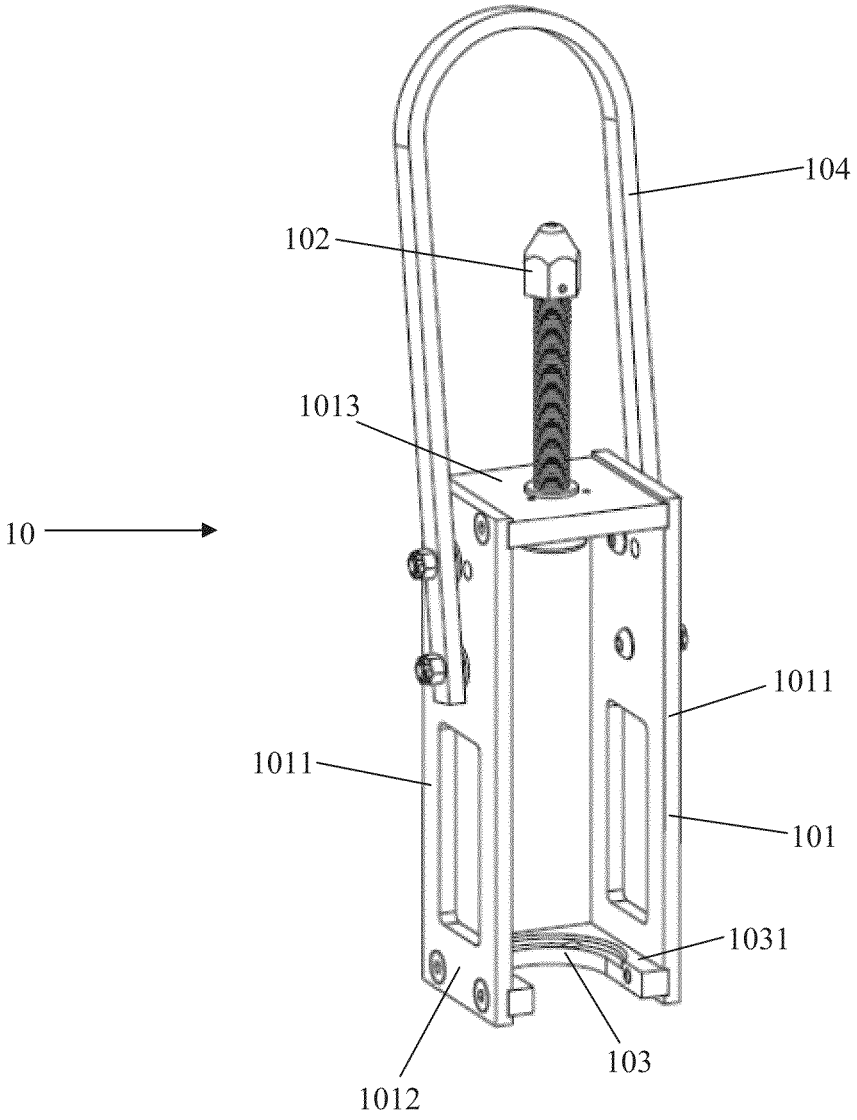


FIG. 3

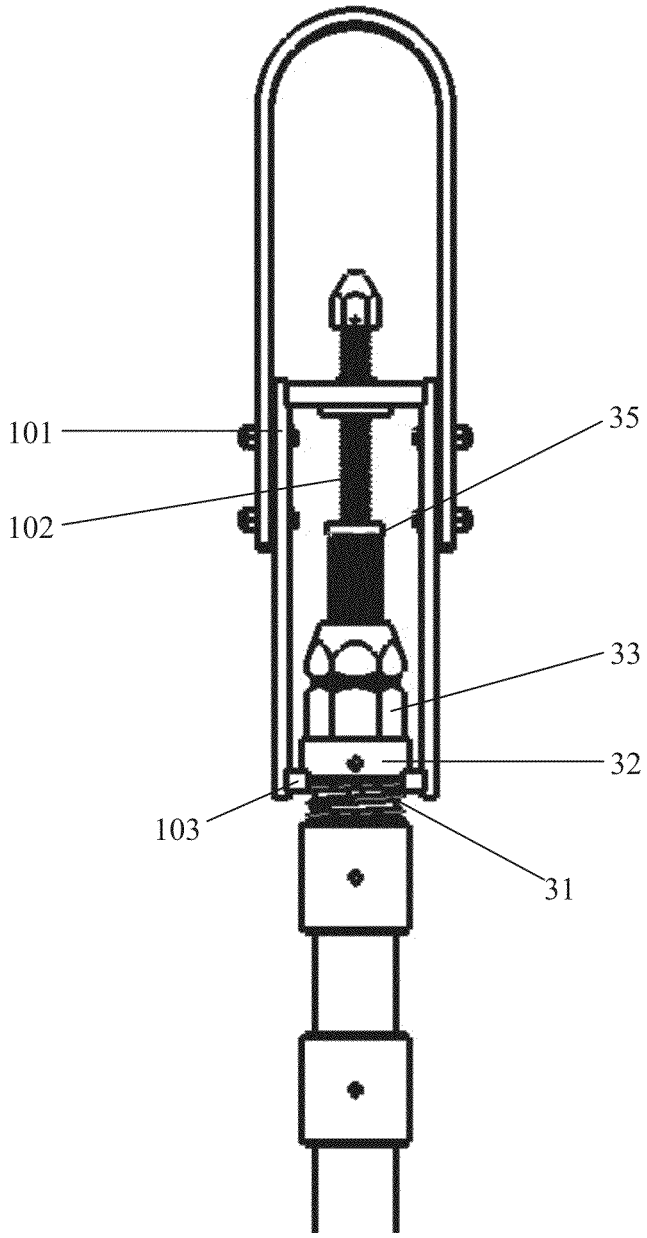


FIG. 4

BOILING WATER REACTOR CORE SHROUD HEAD BOLT RETAINER TOOL

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application claims the benefit of U.S. Provisional Patent Application No. 61/522,511 filed on Aug. 11, 2011, which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a boiling water reactor core shroud head bolt removal tool, and, more particularly, the present invention relates to a tool for ensuring safe removal and installation of core shroud head bolts to the proper position.

2. Description of the Related Art

Core shrouds are components of boiling water nuclear reactors; they are cylindrical structures that surround the core to provide a barrier to separate the downward coolant flow through the annulus from the upward flow through the core. The core shrouds also structurally support and align the fuel assemblies, steam separator assemblies, and control rod guide tubes. A head sits atop the shroud and creates an upper plenum into which a two-phase steam/water mixture enters from the core and is directed to steam separation equipment.

The core shroud head must be removed to access the core for refueling and inspection of the core internals. During removal and installation of the core shroud head, it is necessary to de-tension and tension the core shroud head bolts. These bolts have a spring pushing upward against a retainer, which locks the nut on the shroud head bolt assembly, preventing the nut from rotating. Due to many years of service, and with the accumulation of grit and grime, the retainers may not return to the locked position with just spring pressure. What is needed is a tool that ensures removal and replacement of the core shroud head bolts with the spring retainers in the proper position.

SUMMARY OF THE INVENTION

The inventive tool is designed to remove and replace core shroud head bolts, while exerting an upward pulling force on stuck retainers, returning them to the locking position around the nut. The tool includes a relatively stationary base or frame, a collar, and an engagement member. With the core shroud bolt in position on the shroud head, tool is positioned about the nut portion of the core shroud bolt assembly such that the frame spans the length of the nut portion with the collar positioned beneath the retainer and the engagement member positioned above the end portion of the bolt. The engagement member, which may be provided in the form of a hex nut, is tightened until its stop seats against the top of the shroud head bolt. Additional torquing of the engagement member causes the tool housing, including the lower collar, to rise up, which in turn pulls the shroud head bolt, retainer back into its lock position.

DESCRIPTION OF THE DRAWINGS

The present invention is described with reference to the accompanying drawings, in which like reference characters reference like elements, and wherein:

FIG. **1** shows a typical commercial boiling water reactor, partially cut-away;

FIG. **2** shows a detailed view of a typical core shroud head bolt;

FIG. **3** shows an embodiment of a tool of the present invention; and

FIG. **4** shows the tool of FIG. **3** in position on a core shroud bolt.

DETAILED DESCRIPTION OF THE INVENTION

In a typical commercial boiling-water reactor, such as illustrated in FIG. **1**, the core inside the reactor vessel creates heat, a steam-water mixture is produced when water (reactor coolant) moves upward through the core, absorbing heat. The steam-water mixture leaves the top of the core and passes through moisture separation equipment where water droplets are removed before the steam is allowed to enter the steam line. The steam line directs the steam to the main turbine, causing it to turn the turbine generator, which produces electricity. The unused steam is exhausted into the condenser where it is condensed into water. The resulting water is pumped back to the reactor vessel.

The reactor core contains fuel assemblies that are cooled by water circulated therethrough. A majority of coolant flows down through an annul us created between the reactor vessel wall and the core shroud **1**, while a portion of the coolant is directed through jet pumps located within the annulus that ensure proper flow upward through the core.

A head **2** sits atop the core shroud **1** and creates an upper plenum into which a two-phase steam/water mixture enters from the core and is directed to steam separation equipment. The head **2** is attached to the shroud **1** by a plurality of core shroud head bolts **3**, a detailed view of which is presented in FIG. **2**. A typical shroud-head bolt **3** is 1.75 in. in diameter and 14 ft long. A nut is screwed onto one end of the bolt, and a tee head is welded to the other. A sleeve covers the rest of the bolt **3**, and the base of the sleeve is joined to a collar that is welded to the shaft near the tee head. A part of the collar is cut out to provide space for an alignment pin window.

The head **2** must be removed from the shroud **1** to access the core for refueling and inspection of the core internals. During removal and installation of the core shroud head **2**, it is necessary to tension and de-tension the core shroud head bolts **3**. These bolts **3** have a spring **31** pushing upward against a retainer **32**, which locks the nut **33** on the shroud head bolt assembly **3**, preventing the nut **33** from rotating. Due to many years of service, and with the accumulation of grit and grime, the retainers may not return to the locked position with just spring pressure.

FIG. **3** illustrates an embodiment of a tool **10** for removal and replacement of the core shroud head bolts while ensuring the retainers **32** are returned to the proper position, and FIG. **4** illustrates the tool **10** in position on a mock-up core shroud bolt **3**. The tool **10** includes a base or frame **101**, an engagement member **102**, and a collar **103**.

As shown in the exemplary embodiment illustrated in FIGS. **3** and **4**, the frame **101** may include elongate arms **1011** that provide a height element to the tool **10** such that it spans the distance between the spring **31** and the uppermost end of the nut **3** with clearance to maneuver the tool **10** around the nut **3**. The frame **101** may include a panel **1013** at one end thereof. Preferably, the panel **1013** is oriented such that it is substantially perpendicular to the longitudinal axes of the arms **1011**. The panel **1013** is preferably secured to an end of each arm **1011**. Pairs of arms **1011** may be connected at their second end distal from panel **1013** by a transverse arm **1012** extending between the elongate arms **1011**. The transverse arms **1012** may be separate elements or may be integral to

their associated elongate arms **1011**. By connecting the distal ends of the elongate arms **1011**, the transverse arms **1012** help ensure a robust frame **101** that can withstand the stresses and strains of normal use. Two such transverse arms **1012** are shown in the illustrated embodiment of FIGS. **3** and **4**, but at least a third transverse arm could also be included. One side of the frame **101** should be left open, however, to facilitate placement of the tool **10** on the bolt **3**.

The engagement member **102** is movably coupled to the frame **101**. Preferably, the engagement member **102** is threadably coupled to the panel **1013** such that the longitudinal axis of the engagement member **102** is substantially parallel to the longitudinal axes of the elongate arms **1011** and substantially perpendicular to the plane of the panel **1013** and the longitudinal axis of the transverse arms **1012**. Ideally, the engagement member **102** is substantially centered in the panel **1013** and between the arms **1011**. Thus, the engagement member **102** preferably is coupled to a substantially central location of the panel **1013** with the longitudinal axis of the engagement member **102** being substantially equidistant from each of the longitudinal axes of the elongate arms **1011**.

The collar **103** is coupled to the frame **101** at its second end, distal to the engagement member **102**. Preferably, the collar **103** is connected to each of the transverse arms **1012**. The collar has an arcuate shape that facilitates its placement around the spring **31**. The collar **103** extends inwardly away from the frame **101** in a plane that preferably is substantially parallel to the panel **1013**, thus forming a ledge **1031** that can be used to contact and exert force against the retainer **32**. Preferably, the collar **103** is substantially centered in the frame between the elongate arms **1011**.

After the bolt **3** has been placed in its plant operation position and the nut **33** has been tightened in known manner, the tool **10** is lowered onto the bolt **3** such that the collar **103** is below the retainer **32** and adjacent the spring **31**, and the engagement member **102** is above the uppermost end of the bolt **3**. A crane, such as the plant's overhead crane, in conjunction with an optional handle **104** may be used to accomplish this movement. Proper position of the tool **10** on the bolt **3** can be ensured via line of sight or through the use of cameras (not shown). The engagement member **102** is then rotated in a clockwise direction (from the perspective above the tool **10**), which causes the engagement member **102** to be lowered relative the frame **101**. Such rotation continues until the lowermost end of the engagement member **102** comes into contact with the end or stop **35** of the core shroud head bolt **3**.

Once the engagement member **102** is in contact with the bolt stop **35**, further rotation of the engagement member **102** will cause the frame **101** and collar **103** to move relatively upward, as the bolt stop prevents further downward movement of the engagement member **102**. As the collar is initially positioned adjacent the spring **31**, it will come into contact with the retainer **32**, and with continued engagement member **102** rotation will lift the retainer **32** and extend the spring **31**. Preferably, the ledge **1031** portion of the collar **103** contacts and exerts force against the retainer **32**. Thus, rotating the engagement member **102** to impart a downward force via the engagement member **102** results in an upward force imparted to the retainer **32** via the collar **103**. When it has been determined that the retainer **32** and spring **31** are in their proper plant operation position, the engagement member is rotated in the opposite (counter-clockwise) direction to lower the frame **101** and collar **103**, and to back the engagement member **102** away from the bolt **3** so that the tool **10** can be removed.

While the preferred embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only, and not of limitation. It will be apparent to persons skilled in the relevant art that various changes in form and detail can be made therein without departing from the spirit and scope of the invention. Any directional orientation references hereinabove, such as above or below, are provided for ease of explanation and understanding, and should not be taken as limiting. Thus the present invention should not be limited by the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents. Furthermore, while certain advantages of the invention have been described herein, it is to be understood that not necessarily all such advantages may be achieved in accordance with any particular embodiment of the invention. Thus, for example, those skilled in the art will recognize that the invention may be embodied or carried out in a manner that achieves or optimizes one advantage or group of advantages as taught herein without necessarily achieving other advantages as may be taught or suggested herein.

What is claimed is:

1. A tool configured to reposition a spring-biased retainer of a boiling water reactor core shroud head bolt about a head bolt nut, the tool comprising:

a frame having a first end and a second end, said frame defining a side opening and including:

a plurality of elongate arms each having first and second ends, a length, and a longitudinal axis,

a first transverse arm coupled to a first pair of said plurality of elongate arms at their second ends, and a second transverse arm coupled to a second pair of said plurality of elongate arms at their second ends;

an engagement member coupled to said frame at said first end such that said frame and said engagement member are relatively movable; and

a collar coupled to said frame at said frame second end, said collar defining an opening therein, said collar opening being aligned with said frame side opening, and said collar being configured to engage the retainer;

wherein said collar is coupled to said first and second transverse arms and extends inward toward a center of said frame; and

wherein the tool is configured to exert a repositioning force to the retainer upon engagement of said engagement member with the core shroud head bolt.

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